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Geoscientific
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Discussions

Interactive comment on "A dynamic continental runoff routing model applied to the last Northern Hemisphere deglaciation" *by* H. Goelzer et al.

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**Note my system email address is above in inaccurate, correct is lev@mun.ca

This submission describes a newly developed surface drainage solver with post-processing lake storage. The submission briefly includes sample application to the last deglaciation and sensitivity to grid resolution of the drainage solver. The apparent intent is to validate this solver for glacial cycle (or at least deglacial) drainage modelling. The solver offers nothing new over previous solvers (eg Tarasov and Peltier, 2005/6). Furthermore, surface water storage is only implemented in post-processing form (unlike Ibid which has dynamic surface water storage). As I understand, the purpose of this journal is to document models, and there is no need for the models to be "better" than previous models. What I do find misleading is that this submission tries to sell a

trival innovation that is in fact not innovative (as detailed below), and it fails to clearly compare the features of the described solver to previous ones in the literature and to document sources of error resulting from model approximations.

My major concerns are:

1) The hydrologically-self-consistent HYDRO1k topographic data-set should be used, and not ETOPO5. One also needs to verify that critical sill elevations are preserved under coarse-graining.

2) There needs to be clearer (ie quantitative) validation of the derived drainage basins with this solver. How do drainage basins areas compare to that of the HYDRO1k dataset? Could consider including side by side plots of present-day modeled and HYDRO1K drainage basins.

3) Relatedly, given the size of major drainage sills/chokepoints, an accurate deglacial drainage calculation with a 50km grid resolution ice sheet model has to take into account changes in past sill elevations and sub-grid ice margin position for certain critical choke points (cf Tarasov and Peltier, 2006). None of these issues are even mentioned in this submission.

4) As detailed below, I know from my own work that the coarsened (in this case via subsampling of a Gaussian filtered higher res version) 50 km version of the ETOPO5 DEM with the stated hand edits is inadequate for accurate deglacial drainage modelling, contrary to the stated conclusion.

5) It should be mentioned that the lack of dynamic surface water storage (lakes), means that computed surface elevations will have an extra source of error whenever proximate to pro-glacial lakes (since the surface load for isostatic adjustment determination is missing the water load). Furthermore, this deficiency precludes modelling of lake calving.

################### Specific comments: ###################

abstract: should be more precise with "considers changes in water storage and lake drainage", as the water storage is only implemented in post-processing form

" 2005), our approach is novel in the following aspect: it specifically addresses the problems that arise from the combination of a temporally changing topography (as a func- tion of evolving ice thickness and isostatic adjustment) with an ocean model grid that uses a fixed land-sea mask. This represents an important step towards coupled ice-.. ... ocean model grids has to be taken into account, and the changing topography makes it necessary to regularly update the routing matrix automatically and in a computationally efficient way."

##This is a trivial feature to highlight and is not novel. Ie one simply drains downslope, filling depressions along the way, to whatever elevation threshold or other condition (overlap with ocean mask) you want along with some imposed settings on drainage pointers to deal with grid boundaries and such. I already did this back in 2005 (Tarasov and Peltier 2005), with a chosen threshold at the 600 m bathymetric depth (and with topography and drainage mask updated every 100 years, though could have easily been more often).

##What I do find irksome, is that this submission cites Tarasov and Peltier 2005 and yet fails to mention that their algorithm does have dynamic lake storage as part of the drainage module (and not as a post-processing routine, detailed in Tarasov and Peltier 2006).

"flexural rigidity D, meaning that aside from local isostasy, contributions from remote locations are taken into account as well (Le Meur and Huybrechts, 2001)."

##should mention that this type of isostatic adjustment model has been shown to be inaccurate for glacial cycle modelling, (van den Berg et al, 2008). I would submit even more so for drainage modelling given sensitivity to sill elevations.

"5 $\times$ 5 resolution, called ETOPO5 (1998). We favoured the 5 resolution version since a

DEM of higher resolution, which contains bedrock information of e.g. the Great Lakes and ocean bathymetry was not available at the time of model development. Note that"

##This is a lame excuse as one can always merge different topographies.

"current sea level. Furthermore, we increase the ocean mask by extending it radially around each CLIO grid point."

##I don't see any need for this. Simply keep going downslope, filling depressions along the way, until you hit your ocean mask.

" close to the dam lakes " # -> ice-dammed lakes I think? Though did offer some humour.

##Also, how do areas of PD drainage basins compare between your model and that of the hydro1k dataset?

##The resolution sensitivity tests are weak given that there is no indication of whether the modelled deglacial margin chronology has any close relationship to that inferred geologically.

"way. Calculating changes in water storage and consecutive redistribution on the high resolution ETOPO5SP grid, although theoretically possible, is too time consuming. We

"4 Conclusion and discussion It was shown that the large-scale ocean basins and timing of major freshwater forcing periods is relatively stable between versions of different DEM resolution. Hence, for the range of DEM resolutions under scrutiny, the lowest version with 50 km resolution is sufficient for calculating the large-scale runoff pathways necessary to determine the routing of freshwater fluxes to an ocean model. Changes in the isostatic adjustment"

This conclusion is misleading. It only shows little change for the given DEM and deglacial chronology. I know from my own detailed deglacial modelling of North America that vanilla grid coarsening with the stated local edits is inadequate to accurately

model deglacial meltwater drainage pathways (at least when ice margins are subject to geologically inferred constraints). There are, for instance, other critical choke point regions associated with the Eastern and Northern outlets of Lake Agassiz that also require hand editing. How do critical sill elevations in the coarsened grids compare against published values for the eastern Lake Agassiz outlet (Nipigon basin) (Teller and Thorleifson, 1983)? Furthermore, the applied grid coarsening algorithm will significantly change sill elevations for grid cells of sufficient topographic roughness (eg all the controlling sill regions for lake Agassiz drainage). Accurate sill elevations are especially critical for determining paleo lake levels and effective strand-line elevations.

##At 50km there is no reason why you couldn't dynamically compute actual surface water storage. My full drainage solver (ie with dynamic water storage) adds less than 30 minutes to the run-time at that resolution for a 120 kyr continental scale run (running on a single PC core).

Figs: #######

##Would really help to see how PD drainage basins change wrt resolution changes at a time when drainage is sensitive to the exact ice margin position (eg 12-13 ka for North America).

##fig 8., yellow (GOM) line too indiscernable, use a different colour. Also, the presentation does not facilitate comparison. Instead, plot all the resolutions for the same drainage sector on one plot (eg GOM and Pacific), and split different sectors between different plots.

##Instead of displaying the bland 20ka drainage topography, try a much more challenging 12.5ka drainage topography for North America that is in accord with geological constraints on ice margin position. I know from personal experience that meltwater routing during this time is much more sensitive to topographic details.

Interactive comment on Geosci. Model Dev. Discuss., 4, 2723, 2011.